AM BROADCASTING

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AM BROADCASTING

ACHIEVEMENTS: *Introduction to the TIMS broadcasting accessories. Demonstration of wire-less broadcasting across the laboratory, using amplitude modulation - AM.*

PREREQUISITES: *familiarisation with TIMS; completion of experiments dealing with amplitude modulation, envelopes, and envelope detection.*

EXTRA MODULES: *Tx ANTENNA, Rx ANTENNA, 100 kHz Rx ANTENNA UTILITIES.*

Demonstration of AM Broadcasting

In this experiment you will model an AM transmitter, making a signal of the type transmitted by your local AM broadcasting station. You will send a message, or program supplied at TRUNKS, via a pair of antennas, to a remote TIMS SYSTEM UNIT, where the message will be recovered by a receiver fitted with an envelope detector.

Three special TIMS accessories, described below, are available to model the antenna systems. They allow you to simulate wire-less broadcasting.

Tx ANTENNA

Read about this accessory in the ***TIMS User Manual***.

The transmitting antenna is in the form of a square inductive loop, mounted on a 1 metre stand, and fed by a length of coaxial cable terminated in two 4 mm plugs.

It is intended that the antenna be fed, via the coaxial cable, from the output of a standard BUFFER AMPLIFIER module. The signal level from this amplifier should be adjusted, in the first instance, to the TIMS STANDARD REFERENCE LEVEL [1].

The antenna is broadly tuned to 100 kHz, and is intended for the transmission of any kind of narrow-band signal located in the vicinity of 100 kHz. By narrow-band is

[1] depending upon the distance to the receiving antenna it may be found necessary to increase this signal level. The BUFFER AMPLIFIER is capable of providing an output significantly in excess of the TIMS STANDARD REFERENCE LEVEL before overload occurs.

meant a signal of bandwidth considerably less than an octave; say any where from 85 kHz to 115 kHz.

Rx ANTENNA

Read about this accessory in the ***TIMS User Manual***.

The receiving antenna is in the form of a square inductive loop, mounted on a 1 metre stand, and fed by a length of coaxial cable terminated in a BNC-type coaxial connector.

The antenna is broadly tuned to 100 kHz, with a useful bandwidth of about 85 kHz to 115 kHz.

The antenna is intended for the reception of signals transmitted from a TIMS Tx ANTENNA.

100 kHz Rx ANTENNA UTILITIES

Read about this module in the ***TIMS User Manual***.

For the demonstration of wireless broadcasting the receiving and transmitting antennas may be separated by distances in the range say 2 to 5 metres.

Under these conditions the received signal, measured at the end of the coaxial cable, will be well below the TIMS STANDARD REFERENCE LEVEL - perhaps a few hundred microvolt or less.

To amplify the relatively small signals from the Rx ANTENNA a special purpose 100 kHz Rx ANTENNA UTILITIES module is available.

This module contains a high gain amplifier and a bandpass filter - BPF. The amplifier has an on-board gain control. This is pre-set to suit the range over which the signals are to be transmitted, so as to provide a wanted signal output of approximately the TIMS STANDARD REFERENCE LEVEL

Antenna Placement

The loop antennas are placed adjacent to their respective TIMS SYSTEM UNITS. The separation of the antennas will typically be in the range say 2 to 5 metres. For best reception the loops should be rotated so that their axes are co-linear.

The Transmitter

Set up the AM transmitter of the experiment entitled ***Amplitude Modulation - AM***. This is shown in Figure 1 below, with the addition of a BUFFER AMPLIFIER module and a Tx ANTENNA.

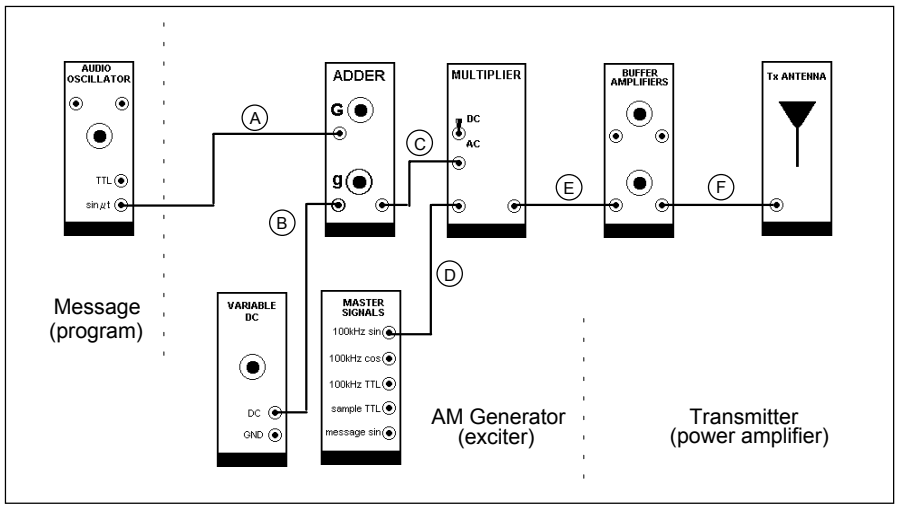

Figure 1: AM Transmitter.

The Power Amplifier

The power amplifier for the transmitter is modelled by a BUFFER AMPLIFIER. If necessary, to provide a larger signal at the receiver, its output may be increased beyond the TIMS STANDARD REFERENCE LEVEL without causing distortion. This may be checked by observation with the oscilloscope.

The Receiver

The coaxial cable from the receiving antenna should be connected to the coaxial input socket of the 100 kHz Rx ANTENNA UTILITIES module.

Typically the Rx ANTENNA will pick up a lot of electromagnetic radiation over the range say 50 kHz to 1 MHz. Some of this will come from remote locations, but some possibly from electronic equipment located nearby (especially some PC monitors). Examination of the signal from the MONITOR OUTPUT of the amplifier in the 100 kHz Rx ANTENNA UTILITIES module will show all this noise, and it is probable that the wanted signal will be lost in it.

The wanted signal will become more prominent if the noisy signal is passed through the in-built BPF. Assuming the transmitter has been set up correctly, the amplitude modulated signal should be visible, at about TIMS STANDARD REFERENCE LEVEL, at the output of this module.

Ideally it should have the appearance of Figure 2, but, despite the BPF, *it will be accompanied by noise.* Further, unless positive steps are taken (see later), the oscilloscope will probably not display a *stable* picture of the AM signal.

If the AM signal is unrecognisable because of noise then the amplitude of the received signal will need to be increased. This can be done by increasing the tranmitted signal amplitude, or moving the two antennas closer together.

Make sure there is at least a recognisable AM signal at the receiver before proceeding. The clearer is the envelope shape then the better the received signal-to-noise (SNR) ratio.

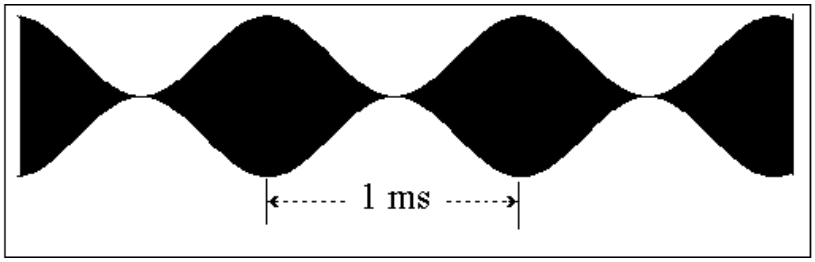

Figure 2: the *ideal* AM waveform

Message Recovery - Demodulation

A simple diode detector is adequate for message recovery from the amplitude modulated signal, provided the received SNR is adequate.

The diode detector can be modelled with an IDEAL RECTIFIER and suitable lowpass filter, such as that in the HEADPHONE AMPLIFIER. This arrangement is examined in the experiment entitled ***Envelope Recovery***.

The complete receiving facility is shown in block diagram form in Figure 3 below.

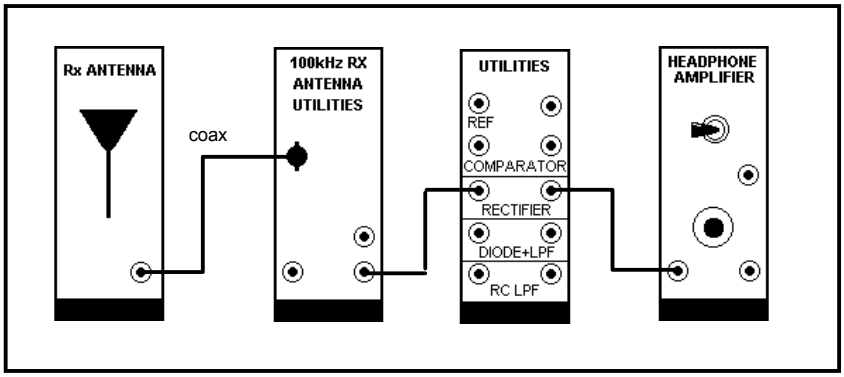

Figure 3: the 'TRF' receiver

This arrangement is known as a *tuned radio frequency* (TRF) receiver. Its ability to select the wanted signal and reject all others (considered as noise) is entirely dependent upon the selectivity of the BPF which precedes the envelope detector.

All those unwanted signals which pass through the BPF combine with the wanted signal to produce a composite signal. The envelope of this composite signal becomes the output from the envelope detector.

The envelope of the composite signal will be a good copy of the envelope of the wanted signal provided all unwanted components are small relative to the amplitude of the wanted carrier. Otherwise the composite envelope will be a non-linearly distorted version of the wanted envelope, and so the recovered message will be a similarly distorted version of the wanted message.

Oscilloscope Synchronization

A stable oscilloscope display, of the waveform of Figure 2, is sometimes achieved by trial and error, when synchronizing to the displayed signal itself. But this is often a

question of good luck rather than good management. Do *not* blame the oscilloscope if synchronization is not possible. The oscilloscope requires *envelope* information, and the synchronizing circuitry of the oscilloscope is generally not designed to extract this from the AM (or any other) signal.

For a stable display of the AM signal it is necessary for the oscilloscope to be *synchronized to the message frequency*. This signal is only available *after* successful demodulation. It should be connected to the *external trigger* input of the oscilloscope.

Some Qualitative Measurements

signal-to-noise ratio - SNR

Examine, with the oscilloscope, the signal from the RX AMP MONITOR and the 100 KHZ BPF OUT sockets, of the 100 kHz Rx ANTENNA UTILITIES module.

The received SNR can be changed by rotating the receiving antenna, or reducing the amplitude of the transmitted signal. While doing this listen to the received signal (if speech or music), or observe it on the oscilloscope (if a single tone). Notice what happens as the received SNR falls.

the Rx BPF

As time permits you should measure the amplitude/frequency characteristic of the BPF (bandpass filter) in the 100 kHz Rx ANTENNA UTILITIES module. For this purpose you will need a sinusoidal signal, variable in frequency in the 100 kHz region - a VCO is suitable. This signal should be connected to the TEST IN socket.

Tutorial Questions

Q1 *describe the effects, as observed at the receiver, of rotating the receiving antenna so its axis was not co-linear with that of the transmitting antenna.*

Q2 *compare and describe the oscilloscope display of the signal from the RX AMP MONITOR, and from the 100 KHZ BPF OUT sockets of the 100 kHz Rx ANTENNA UTILITIES. What is the meaning of the term 'signal-to-noise ratio' in this context ?*

Q3 *The bandpass filter in the 100 kHz Rx ANTENNA UTILITIES module is centred on 100 kHz, and is 'about ± 15 kHz wide'. What might this mean ?*

Q4 *suppose at TRUNKS there were two independent speech signals - say a man and a woman talking on different topics. If you listened to them both simultaneously, after combination in equal amounts in an ADDER, would each be recognisable ? Would there be any distortion of either speaker ? Explain !*

Q5 *suppose there are two signals, A and B, both amplitude modulated with different speech messages (say the man and woman of the previous question). Suppose they were on separate carriers (say 95 kHz and 105 kHz), both of which will pass through the BPF. How would the output of the envelope detector compare with the output of the ADDER in the previous question ? Explain !*

Q6 *note that the carriers of the two AM signals of the previous question are spaced 10 kHz apart. The 3 kHz LPF in the HEADPHONE AMPLIFIER (of the receiver) is ineffective in separating the two speakers. Explain.*

Q7 *suppose your recovered message was severely distorted due to the presence of unwanted frequency components in the range 85 kHz to 115 kHz at the output of the BPF. This distortion was* ***not*** *the fault of the envelope detector, which has faithfully recovered the envelope. It was the* ***envelope*** *which was distorted. Think about the possible performance if a synchronous demodulator (sometimes called a 'product detector') was used to recover the message from the output of the BPF. This can form the subject of another experiment.*